ALTITDE-RELATED ILLNESS

By

Col Steve Kinne, MD, MPH

General Preventive Medicine Residency Director

USAFSAM, Brooks City-Base

Denali (20,320 feet)

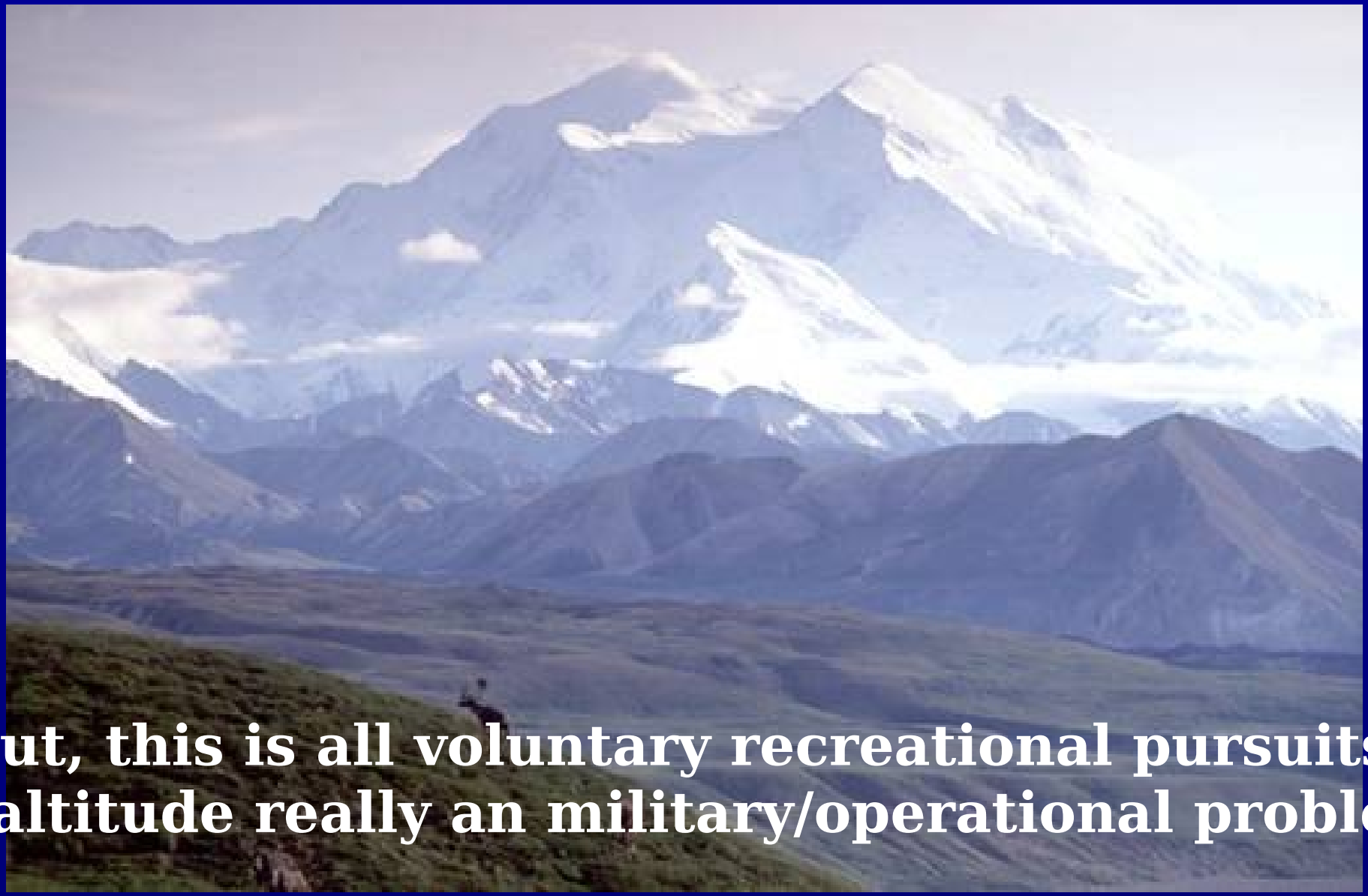
8K

14K

16K

18K

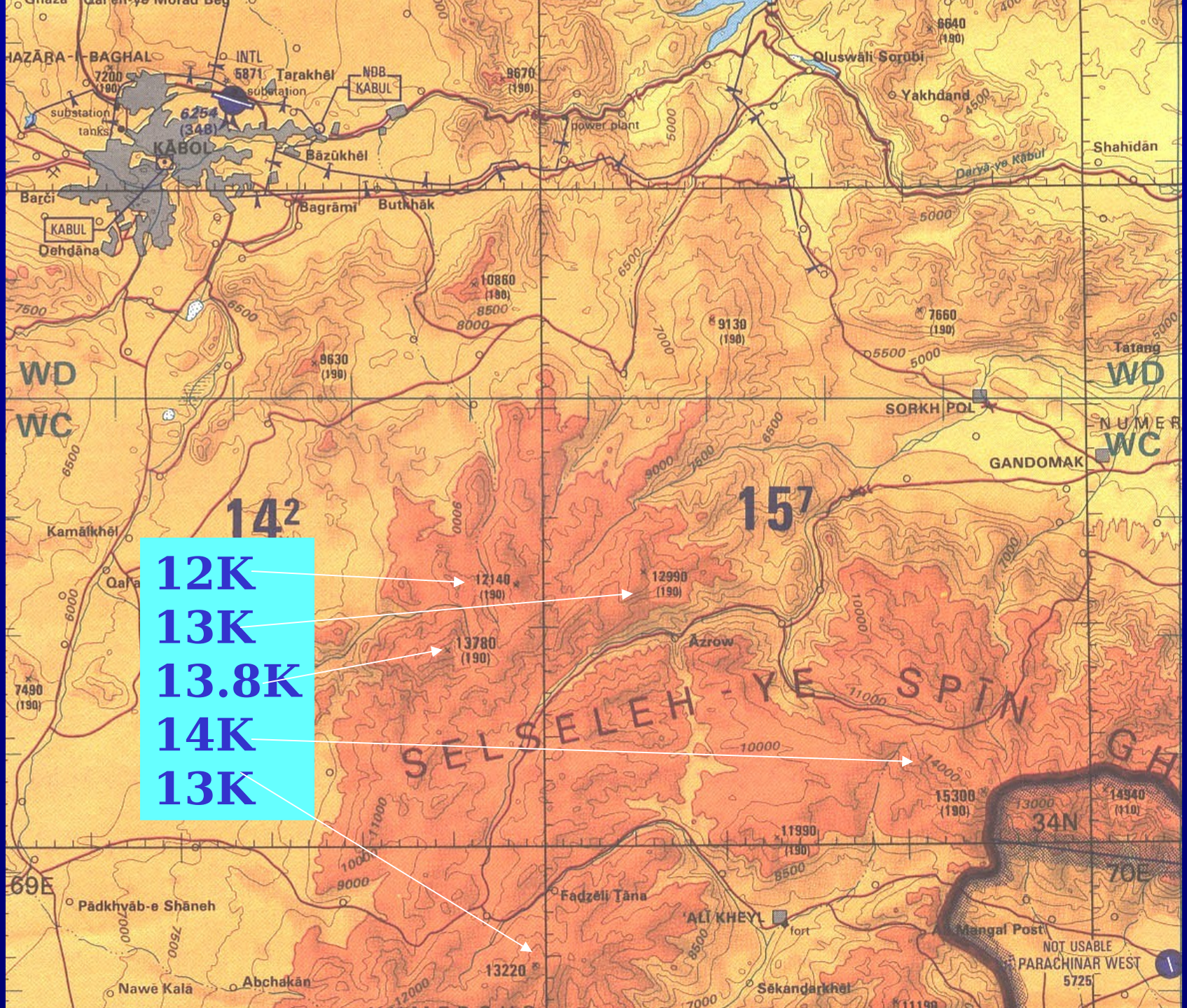
20, 320



But, this is all voluntary recreational pursuits.
altitude really an military/operational proble

Location?
Looking at the Hindu Kus
from Afghanistan

Operation Enduring Freedom

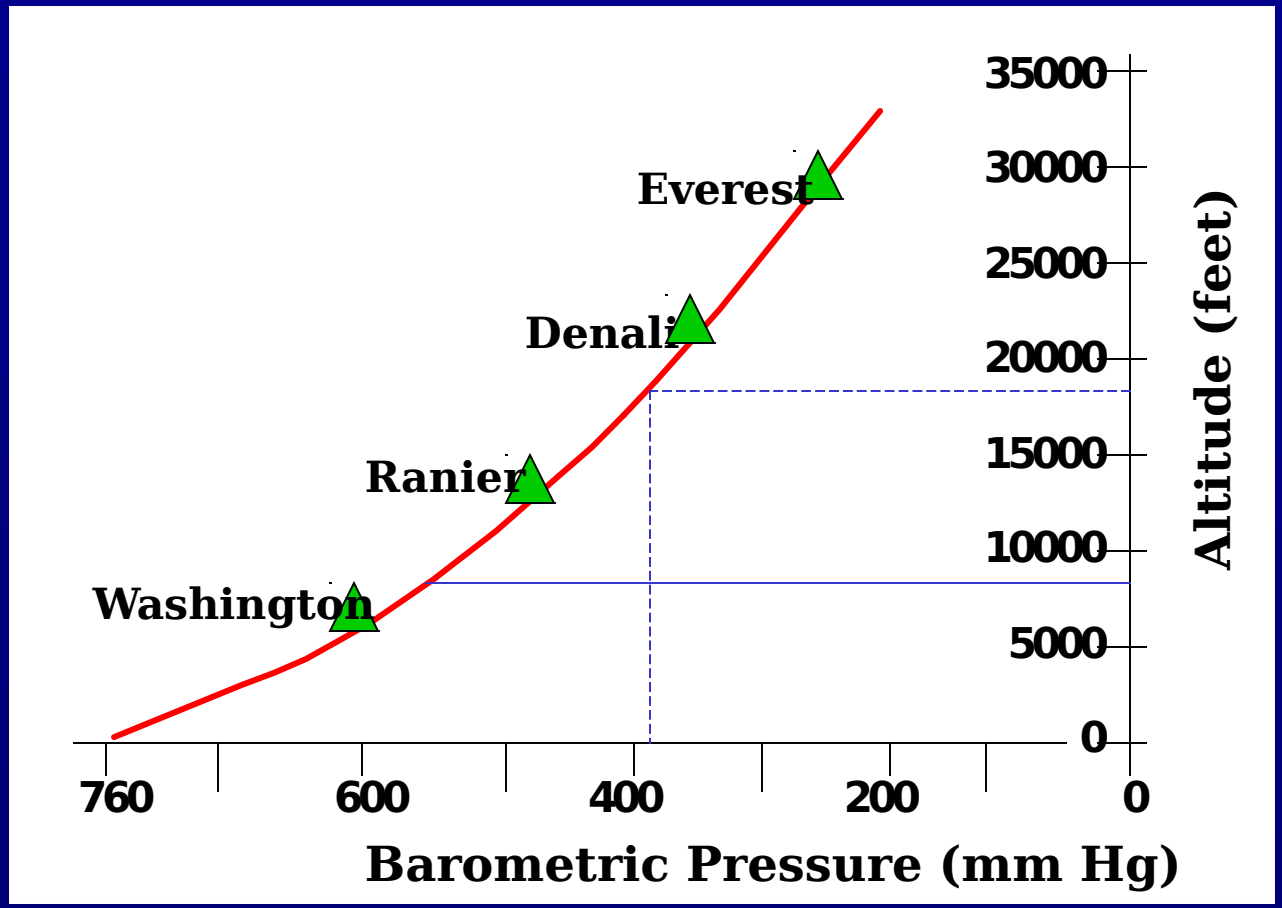

12K
13K
13.8K
14K
13K
KABUL
Tarakhēl
INTL
NDB
KABUL
substation
tanks
6254
(348)
Bāzūkhēl
Barcī
Bagrāmī
Butkhāk
KABUL
Dehdāna
Yakhdand
Shahīdān
Daryā-ye Kābul
power plant
Tatang
SORKH POL
GANDOMAK
WD
WC
NUMER
Kamālkhēl
Qal'a
Āzrow
SELSELEH - YE SPĪN
GH
'ALĪ KHEYL
fort
Mangal Post
NOT USABLE
PARACHINAR WEST
5725
Pādkhvāb-e Shāneh
Fadzēli Tāna
Nawe Kalā
Abchakān
Sēkandarkhēl
34N
69E
70E
14²
15⁷
12140
(190)
12990
(190)
13780
(190)
15300
(190)
14940
(110)
13220
11990
(190)
10860
(190)
9630
(190)
9670
(190)
9139
(190)
7660
(190)
8640
(190)
7490
(190)
7200
(190)
5871

OEF – High Altitude Operations

Changes with altitude

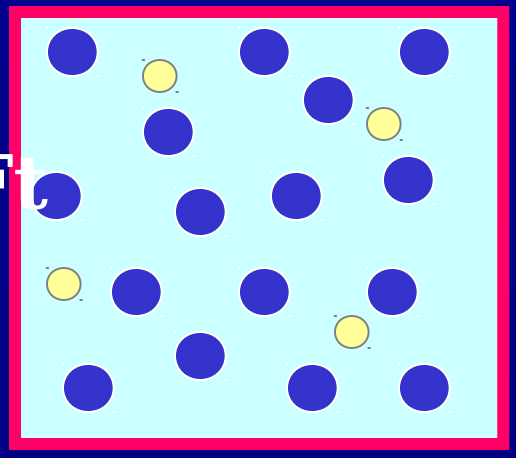
- Deceased barometric pressure
- Decreased oxygen (foot stomp!)
- Decreased humidity
- Deceased temp (avg 3-4 deg per 1000 ft)
- Increased UV exposure (watch UV keratitis)
- Increased exposure (e.g. above tree line)
- But good news -no mosquitoes above 6200 ft !

Relationship of Barometric Pressure and Elevation



Atmospheric Pressure and Air

18,000 Ft.

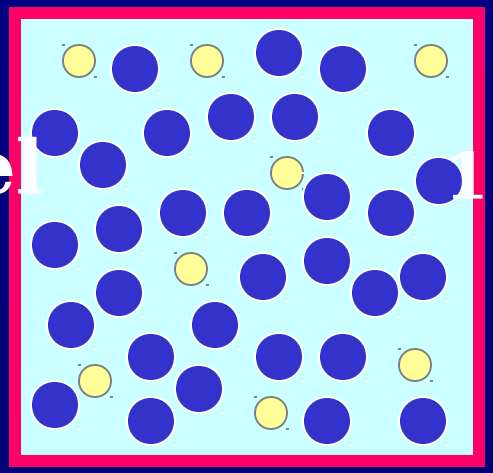


0.5 atm (380 mmHg)

O_2 = 21%

(so, <u>half</u> as much O2)

Sea Level



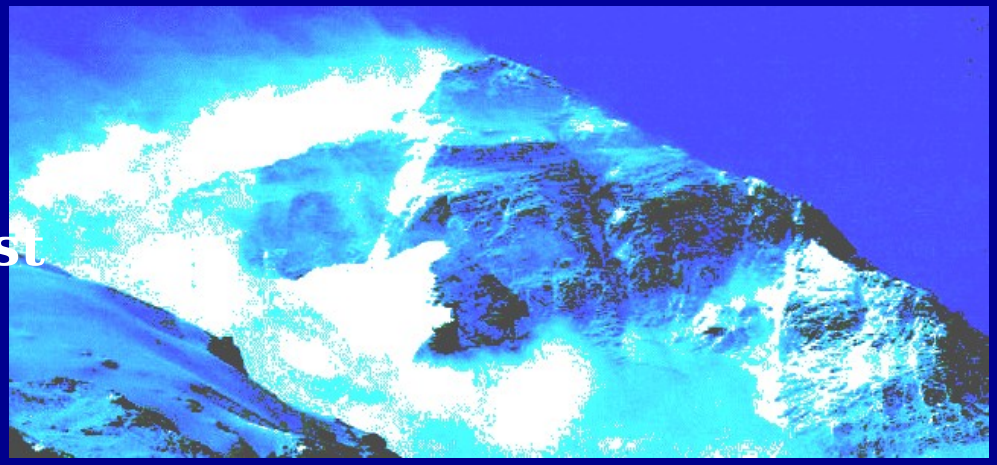
1 atm (760 mmHg)

O_2 = 21%

HYPOXIA IS THE KEY

OK, how high is “high?”

Mt Everest
~29K

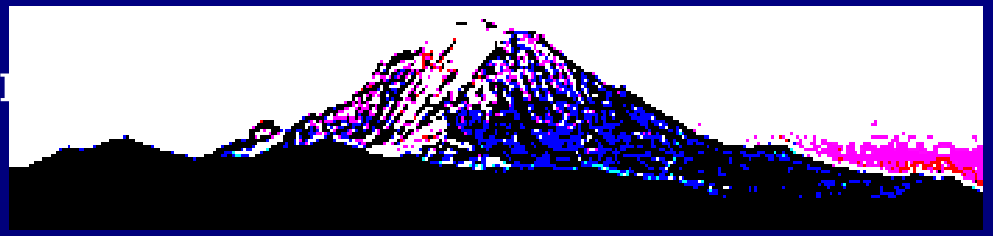


Just Plain
Stupid
>25K

Denali
~20K

Extreme >17

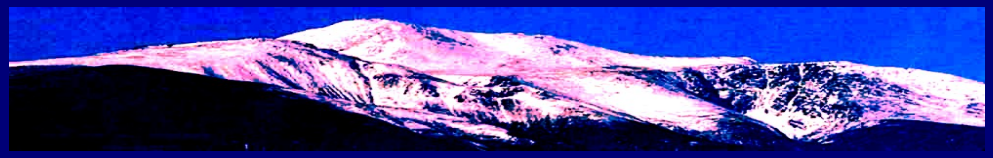
Mt Ranier
~14K



Very High 12-17

High 8K-12K f

Mt
Washington
~6K

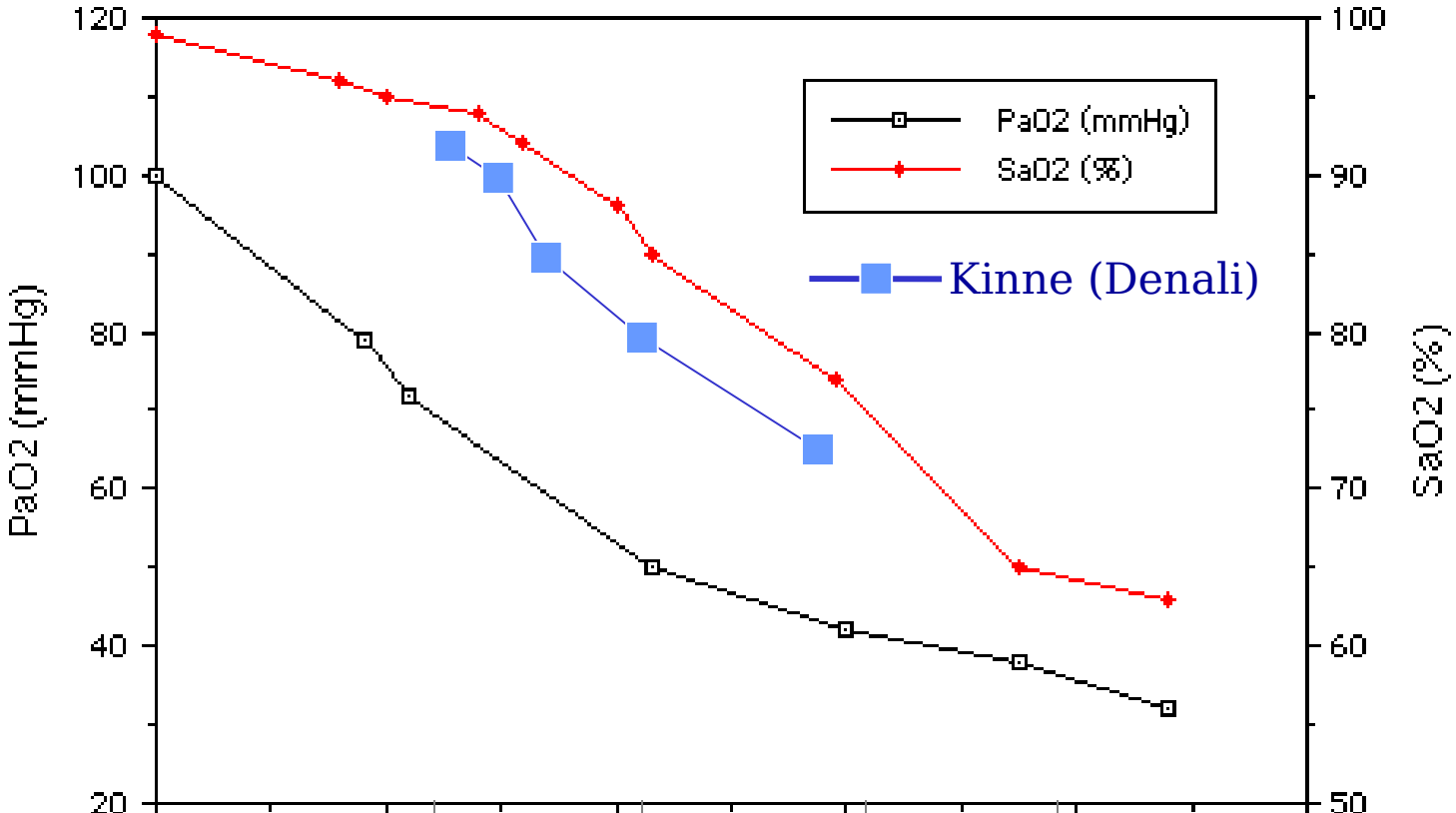


Moderate 5K-8

Changes with (Rapid) Ascent to Altitude

ALT LEVEL	ALT CLASS	SaO2%	PHYS/MED EFFECTS	O2-Hgb Diss Curv
SL-5K	Low	>96%	Minimal	Upper
5-8K	Mod	>92%	Mild	Upper
8-14K	High	80-92%	Inc illness & +Perf degrad	“Knee”
14-18K	Very High	<80%	Illness, perf degr the rule	Steep

Oxygen Saturations at Altitude

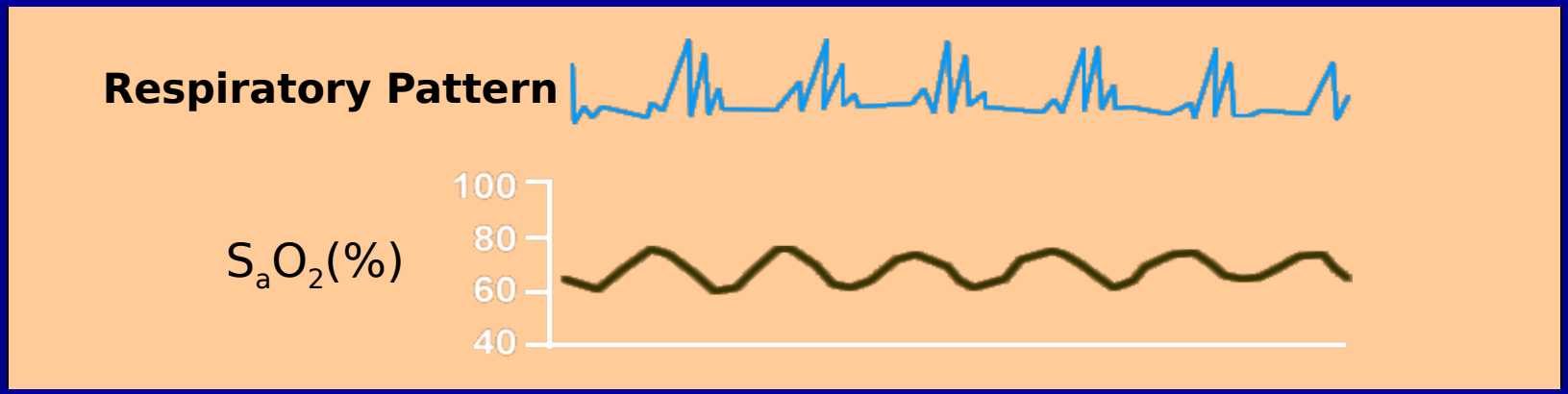


8,000 ft 14,000 ft 20,000 ft 26,000 ft

Normal Physiologic Response

- Hyperventilation (hypoxic vent response)
  - → Exertional SOB → dec CO_2 (resp alk)
- Tachycardia (inc. HR, dec or same SV)
- Increased sympathetic outflow and → venous tone
- Increased cerebral bloodflow
- Increased urination
  - fluid shift & cold diuresis (bld shunted from periphery)
  - Bicarb diuresis (met acidosis to counter resp alk)
- Inc pulmonary pressure (→ pulm hypertension)
- Increased RBC mass –chronic change

Sleep Effects with Altitude



- Altered sleep pattern (periodic breathing)
- Frequent awakening at night (fragmented sleep stages)
- May be a sig factor in development of AMS
- Increased pulm HT during hypoxic periods
- More about this later…

Sleep…

- Light
- Intentional circadian shifting
- Noise (inside and out)
- Pillow, wet clothes, boots
- Muscle fatigue
- Hypoxia

- Eye shades
- Get used to it…being bone tired helps
- Earplugs were key
- Get used to discomfort
- NSAIDs, nutrition
- Diamox?

So, these are “normal” changes as the body adapts (acclimatizes) to the hypoxia environment of high altitude… what happens when one doesn’t adapt?

Acute Mountain Sickness (AMS)

- Rarely develops below 8,000 feet
- Symptoms/signs typically develop within 6-8 hrs of ascent, sometimes as early as 1 hr

AMS-signs and symptoms

- **Headache**

PLUS one or more of the following:

- **Malaise**
- **Anorexia**
- **Nausea/vomiting**
- **Dizziness**
- **Dyspnea on exertion**
- **Dry cough**
- **Inner chill**
- **Low urine output**

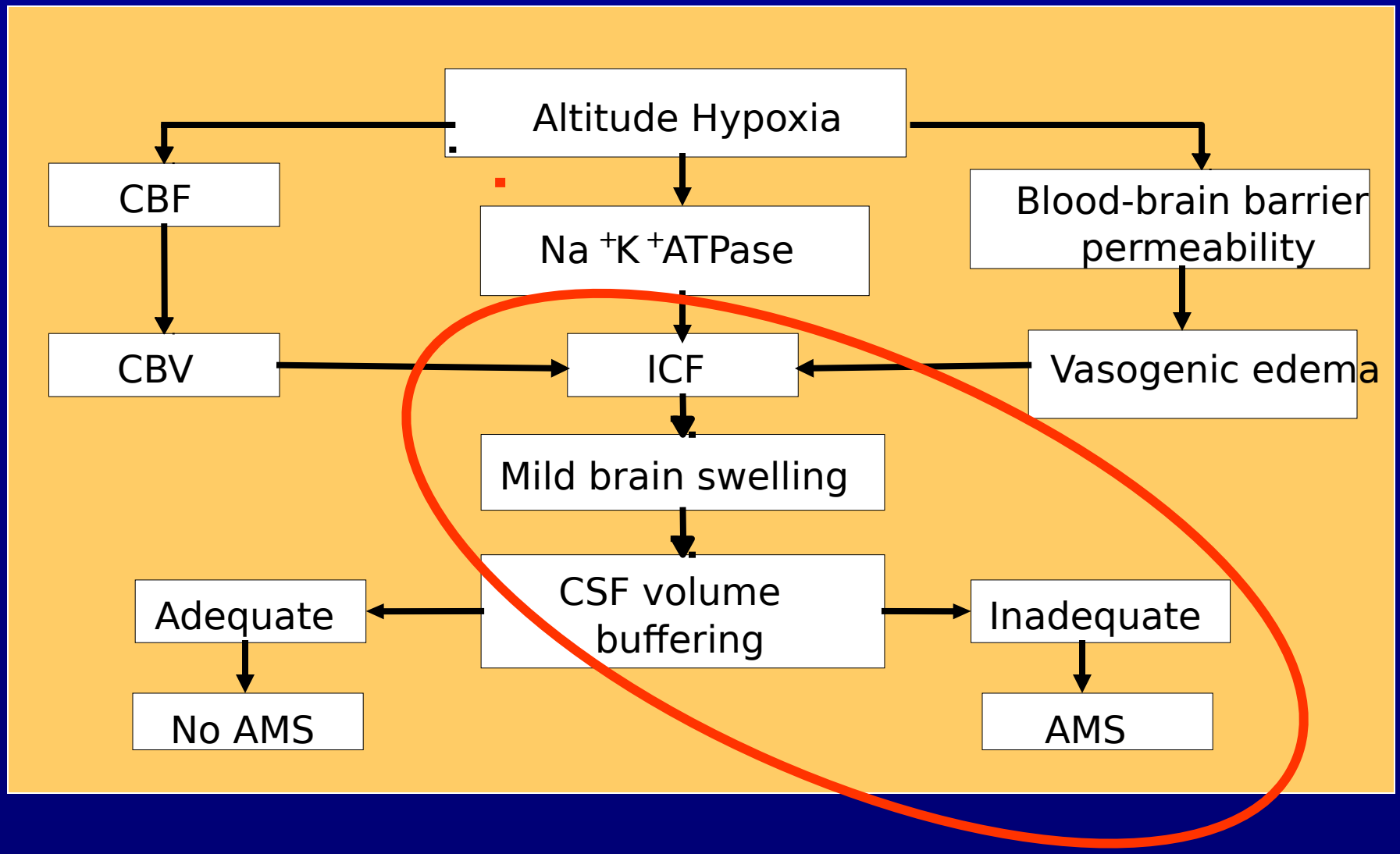
The Cheese-Gorp Affair

Who gets AMS?

- Determining factors
  1. Rate of ascent
  2. Altitude reached
  3. Sleeping altitude
  4. Individual physiology
- Risk Factors
  - Hx of altitude sickness
  - Residing at below 3,000 feet altitude
  - Exertion (esp w/ HAPE)
  - Certain pre-existing cardio-pulmonary conditions

Note: Physical fitness is <u>not</u> protective against a

Pathophysiology of AMS



Incidence of Mountain Sickness

Study Group	# At Risk per Year	Sleeping Altitude	% AMS (# affected)	% HAPE or HACE
Western USA Visitors	40 million	2400-2800 m 7800-9000 ft	15% (6 million)	.01% (4000?)
Mt. Everest Trekkers	6,000	3000-5200 m 9800-17000 ft	35% (2100)	1.0% (60?)
Mt. McKinley Climbers	1,200	3000-5300 m 9800-17400 ft	30% (300)	2-3% (25-35)
Mt.	9,000	3000 m	67% (6000)	?

From Zafren and Hackett

AMS Differential Dx

- **Headache**
- **Malaise**
- **Anorexia**
- **Nausea/vomiting**
- **Dizziness**
- **Dyspnea on exertion**
- **Dry cough**
- **Inner chill**

- Dehydration
- Viral illness
- Hangover
- Exhaustion
- Hypothermia
- Sedative/hypnotic medications
- Carbon

Prevention of AMS

- Acclimatization strategies
  - Staged Ascents
  - Time at altitude
    - Above 10,000 ft, sleeping elevation shouldn't be increased >1,000 ft per night ("Climb high, sleep low" strategy)
    - For every 3,000 ft ascent, spend a second night at the same altitude
  - Mild exercise
  - No ETOH or sleeping meds
  - ? High carbohydrate diet (stim resp drive)

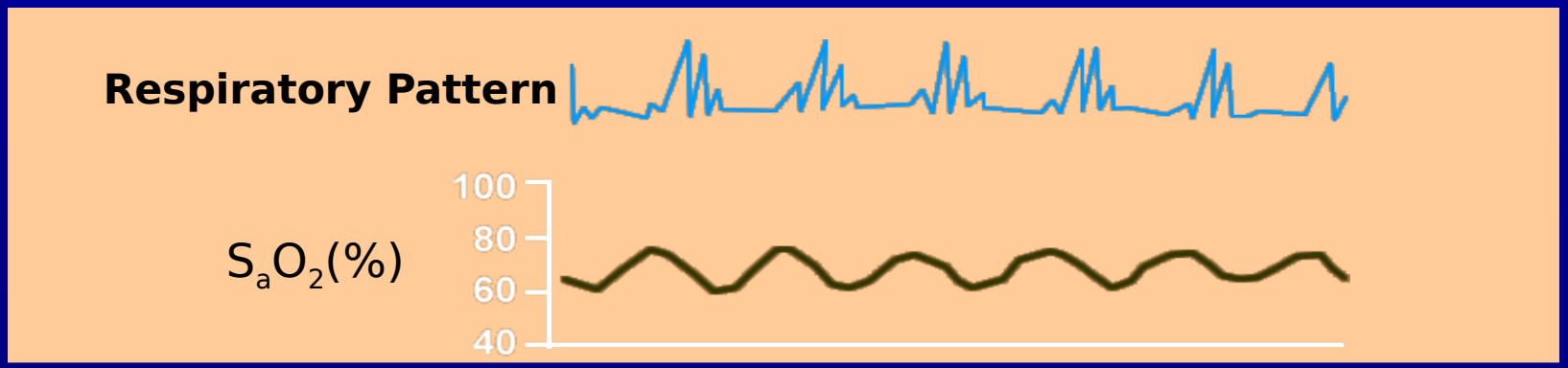
Often not an option during military ops

Prevention of AMS, con't

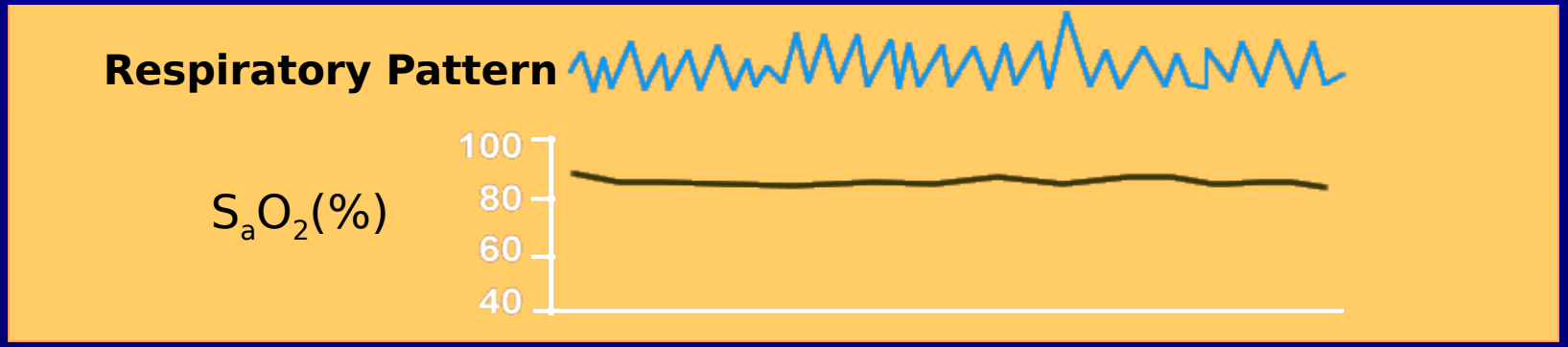
- Medications- Diamox (acetazolamide)
  - Carbonic anhydrase inhibitor
  - Sulfa drug- don't give to sulfa-allergic individuals!
  - Mild-mod diuretic effect, promotes renal excretion of bicarb (→ metab acidosis)
  - Increases ventilatory drive (centrally-acting)
    - Probably the main mode of action
    - Significantly improved sleep!

Effect of Diamox on Periodic Breathing

Without Diamox



With Diamox



Prevention of AMS, cont…

- Who should get Diamox?
  - Rapid ascent, esp to over 9,000 ft
  - Past history of AMS (genetically predisposed?)
  - Development of signs/symptoms of AMS
  - Poor sleep/periodic breathing
    - History of OSA?

Prevention of AMS, con't

- Diamox, cont…
  - May start the day before ascent vs. just as sleeping aid
  - Dosage recommendations:
    - 250 mg bid (or SR 500 mg qd)
    - 125mg bid (or 250 qhs*)
    - 125 mg qhs*
    - 62.5 mg qhs*

      *take at dinner to avoid nocturia
  - May only need it for a 2-3 days (depending on ascent)
  - Side Effects
    - Peripheral paresthesias (esp w/ higher doses)
    - Bad beer!

Prevention of AMS, con't

- Steroids – Dexamethasone
  - Dexamethasone 4 mg po q6hrs
  - Effective by itself, but Diamox more the standard. ? Works only in resting soldiers
  - Occurrence/reoccurrence after stopping
  - May be reserved for sulfa-allergic individuals since they can't take Diamox
  - The combination of Diamox + Dexamethasone may be even more superior

Treatment for Mild AMS

- Rest, hydration, simple analgesics
- Time (i.e. acclimatization).. 12 hrs -days
- Descent
  - As little as 1,000-1,500 ft can improve symptoms significantly
- Start Diamox (as discussed) to speed acclimatization
- Low flow O_2 if available

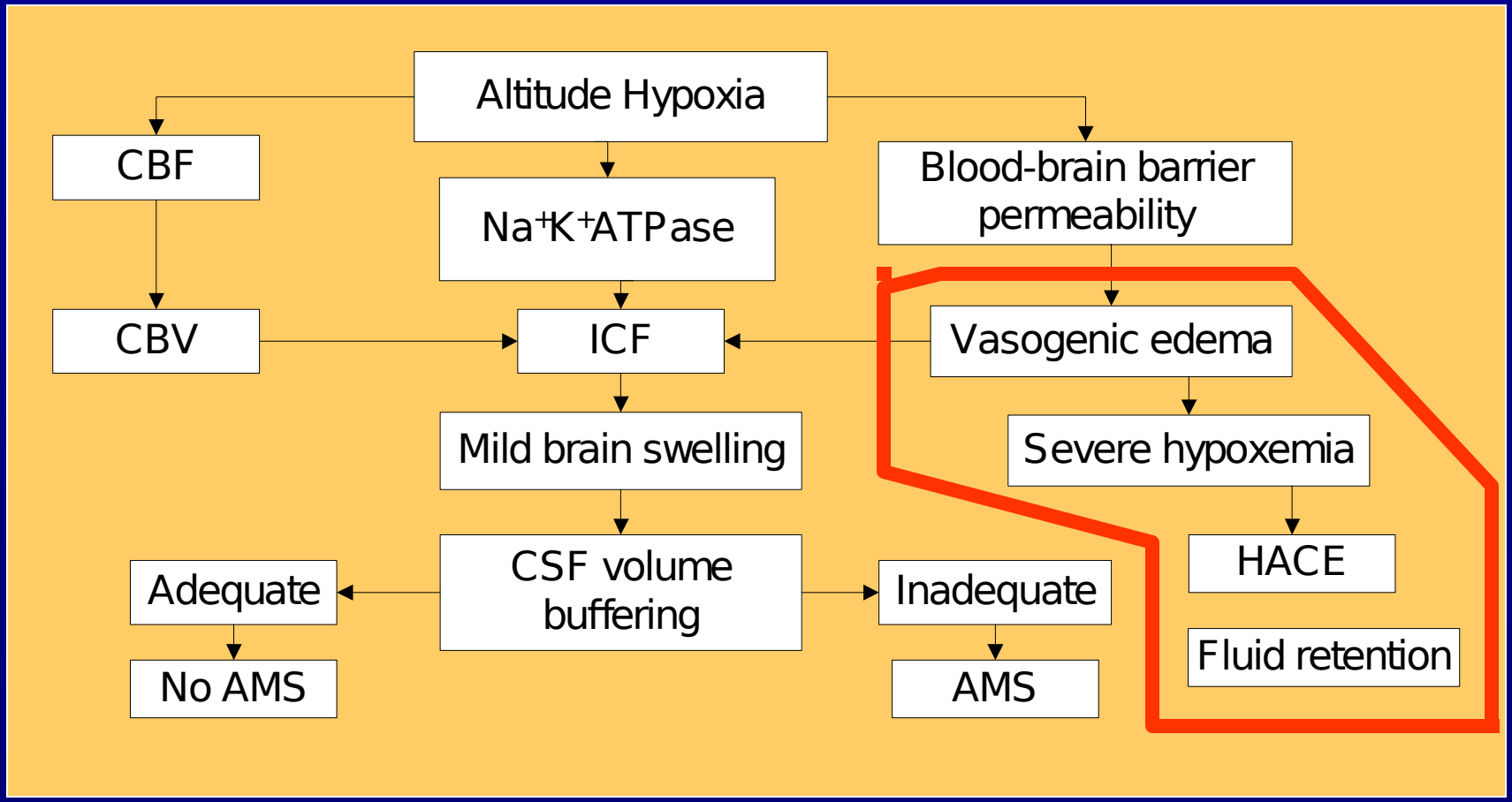
Treatment for Mod-Severe AMS

- DESCENT
- Diamox (as discussed)
- Dexamethasone 4mg po/IM/IV q6Hrs
- Low flow O2
- Portable hyperbaric chamber (2 psi=5K elev drop)

High Altitude Cerebral Edema (HACE)

AMS → **HACE**

Pathophysiology of HACE



Signs/Symptoms of HACE

- Progression of cerebral s/s of AMS (headache, vomiting, dizziness, malaise)
- Truncal ataxia
- Focal neurological deficits (may be asymmetric)
- Severe lassitude
- Altered consciousness or coma

Note: HACE is especially common with co-existing HAPE (pulmonary edema)… exacerbates hypoxia!

HACE

- **Ataxia is the single most useful sign for recognizing the progression of mild AMS to severe AMS and/or HACE. This represents a life threatening condition. Descent is mandatory!**

HACE

- **Diff Dx**
  - **Dehydration**
  - **Exhaustion**
  - **Hangover**
  - **Migraine**
  - **TIA/Stroke**
  - **Brain tumor**
  - **CO poisoning**
  - **CNS infection**
  - **Acute psychosis**
  - **Hyponatremia**
  - **Hypothermia**
- Treatment
  - **DESCENT ASAP!**
  - **O_2 (low-mod flow)**
  - **Gamow bag (Hyperlite)**
  - **Dexamethasone**
  - **Diamox**
  - **Antiemetics**

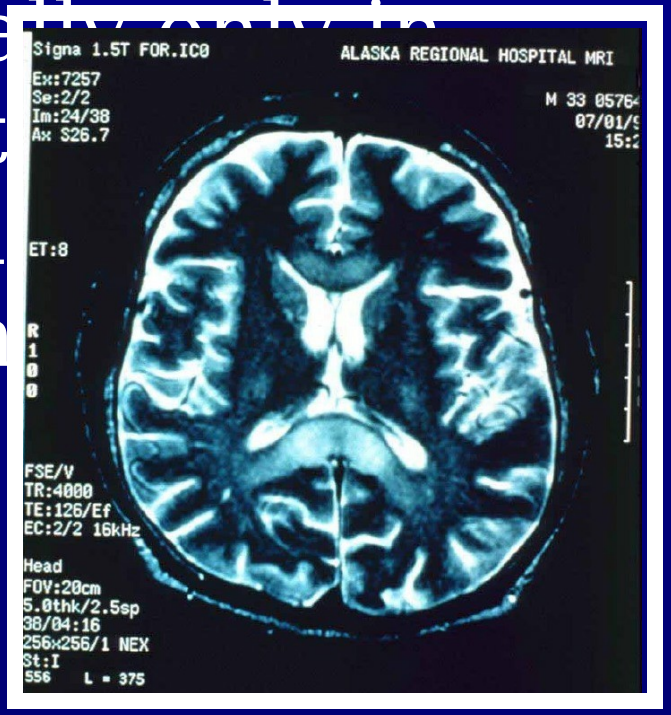
Gamow Bag… “descent” when you can’t go down right away

Temporizing measure… a Gamow Bag can be lifesaving when descent is not possible or may be significantly delayed

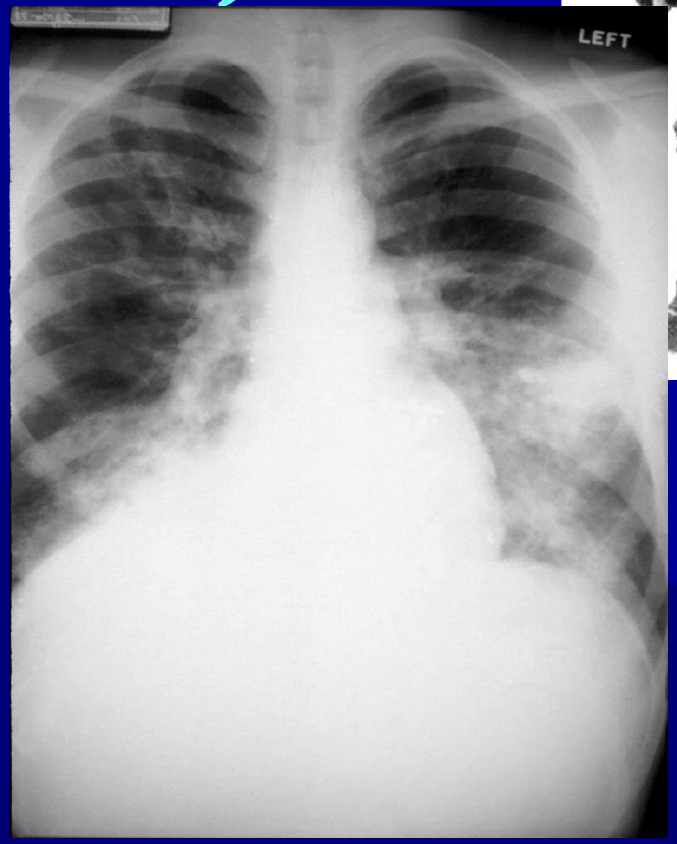
Recovery from HACE

- May be rapid after descent and treatment
- Residual effects usua
  severe cases (i.e. wit
  ischem
  mech

  damage
  brain swelling)



High Altitude Pulmonary Edema (HAPE)



Who gets HAPE?

- Typical profile:
  - Young, fit men with rapid ascent from sea level to >8-9,000 feet altitude
  - May never had had problems with HAPE before (although a history of HAPE is pre-disposing)
- Usually occurs in first 2-4 days post-ascent
  - Most common on second night

Symptoms/Signs of Mild HAPE

- Dyspnea on Exertion
- Persistent dry cough
- Fatigue while moving up hill
- Increased HR but not persistently tachycardic
- +/- localized rales

Symptoms/Signs of Mod-Severe HAPE

- Extreme fatigue (even walking on level ground)
- Tachycardia
- Persistent cough, now raspy or productive
- Dyspnea at rest ** (real red flag)
- Chest tightness, rales
- Cyanosis, ataxia, stupor, coma (late)

HAPE

- Diff Dx
  - Asthma
  - Bronchitis
  - Pneumonia
  - CHF
  - MI
  - PE
  - HVS

- **Treatment**
  - **DESCENT!**
  - **O_2 (higher flow)**
  - **Gamow Bag (temporizing)**
  - **Nifedipine SR 30mg q12hrs to reduce pulm artery press**
  - **Diuretics (e.g. lasix)… note: Diamox not much use**
  - **?beta agonists**
  - **No steroids (unless co-exiting HACE)**

Other altitude-related syndromes

Other altitude-related syndromes to be aware of

- Peripheral edema (common)
- Thrombosis
- High altitude pharyngitis/bronchitis (common)
- HAFE (all too common!)
- High altitude retinopathy
- High altitude syncope
- Altitude-associated migraine

Who shouldn’t go to high altitude?

- Uncontrolled CHF
- Pulmonary hypertension
- Sickle cell disease (hypoxia → SC crisis)
- Significant COPD

Take Precautions with:

- CHF
- Arrythmias
- Cerebrovascular disease
- Sleep apnea
- Seizure disorder
- Pregnancy
  - Pregnant lowlanders shouldn’t go >18,000 ft
  - Pregnant lowlanders shouldn’t stay at >14,000 ft

Altitude-Related Illnesses
Remember these facts

- Hypoxia is the problem
- 8,000 ft is the “floor”
- Acclimatization is #1 means of prevention
- Diamox is #2 when you don’t have the luxury of acclimatizing (use daily or as “sleep aid”)
- AMS is common – think of it!
- HACE – ataxia raises the red flag
- HAPE – dyspnea at rest raises the red flag
- DESCENT is the treatment of choice!

Questions?

Case Study – Op Anaconda

- Mid-30's Army E-6, special forces
- Op Ananconda
  - Based at (Bagram (5K)… rapid Insertion (~12K)
  - Mission cut off fleeing Taliban and destroy weapons caches. Search commenced immed after landing
  - Within 8-12 hrs →severe HA + visual disturb L eye
  - Dx'd possible HACE, sent back down to Bagram
  - Treated with oxygen and Dexamethasone
  - Some improvement, but persisting symptoms after 2 days. Requested Opthalmology consult at Landstuhl

Case Study – Op Anaconda, cont.

- Theater now had CSH in Kuwait with neuro and opthal consultants
- AE’d him to Seeb, Oman (SL) to EMEDS+25
- Noted retinal hemorrhages… HA and visual changes resolved completely within 24 hrs
- CT normal
- Subsequent Opthal eval ain Kuwait normal
- Neuro eval negative except additional Hx

Case Study – Op Anaconda, cont.

- Hx of recurrent, although relatively mild and relieved by OTC meds. No classic migraine symptoms and no FHx migraines
- Neuro Dx: Migraine
- Additional: AMS (onset with rapid ascent, retinal hemorrhages, etc.)
- Migraines may be precipitated by AMS
- Future status??? Limitations???